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System Readiness Assessment (SRA) An Illustrative Example

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Abstract

This paper describes in detail and provides an illustrative example of a Systems Readiness Assessment (SRA) Engineering Process. Implementation of the SRA process can help to improve performance management for systems and aid decision makers in identifying programmatic and technical risk areas. The criteria and metrics used in performing an assessment are described and sample calculations are provided. A set of guidelines is also given for effective implementation and use of the SRA process. The intended users include Program Managers, Lead Systems Engineers (LSEs), Systems Engineers, Independent Review Teams (IRTs), and developers. The goal is to provide the reader with a fundamental understanding of how to conduct an SRA, as well as assist the experienced user in maximizing the benefits derived from performing SRAs.

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Keywords: system; readiness; assessment; technology

1. Introduction

As systems become more and more complex, it is critical to develop a more comprehensive understanding of the development status, or "system readiness," to aid more informed system-level technical and managerial decisions throughout the life cycle. To develop potential system-level metrics, a greater emphasis must be put on the integration between and among individual components. During large-scale developments, it is also critical to measure the system

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readiness at multiple points along the life cycle to avoid pitfalls that can occur when readiness is only assessed once or twice. The SRA process provides visibility over the course of the development life cycle into the entire system and the system's interfaces to external entities.

The SRA process gives decision-makers awareness as to a system's holistic state of maturity and quantifies the level of integration a specific component has attained with other components during system development. The assessment is a critical part of achieving the goals of improved system performance management and of reduced program and technical risk. The SRA enables more effective system development management and integration that can ultimately lead to shortened delivery timelines. Both recent academic efforts and internal expertise have been leveraged to develop this SRA process. Much of the system-level readiness work has been adapted and enhanced from the research conducted at Stevens Institute of Technology. The SRA process described in this paper is being piloted on a number of NSA programs.

Unlike the Technology Readiness Assessment (TRA), the SRA process provides a "whole system" perspective, enabling traceability throughout the entire system. While the Technology Readiness Assessment (TRA) is a Department of Defense (DoD) directive and will continue to be performed across the DoD [1], the SRA process is a significant enhancement and provides a number of additional benefits not provided by the current TRA process. The SRA:

- Measures the readiness of all system components (consider all elements equally critical).
- Focuses on the readiness of integration between components internal to the system and requires readiness understanding of other external dependencies.
- Is performed at multiple times over the course of the system life cycle and not just at major milestone decisions.

SRAs should be performed early in the program to enable the Program Manager to understand and scope the system being built. The initial SRA is best performed at the beginning of the system development life cycle but can be performed at any time during the life cycle. By furnishing a comprehensive systems view, the SRA enables developers and systems engineers to perform design trade-offs and make sound design decisions. The SRA gives the Program Manager an overall system perspective so that resources can be effectively applied in the most pertinent areas. The SRA process also supports portfolio management. When applied to systems across the enterprise, the SRA approach can provide a picture of both developmental and operational systems, with insight not only into the readiness of individual system components and functions but into enterprise capability readiness as well. [4]

2. Metrics

This section describes the five metrics used throughout the SRA process. Two of these metrics, the Technology Readiness Level (TRL) and Integration Readiness Level (IRL), are assigned. The three remaining System Readiness Metrics (Component SRL, Composite SRL and SRL) are computed. Sample calculations for determining specific metrics are provided in Section 4.

2.1. Technology Readiness Level (TRL)

The TRL is a systematic metric/measurement to assess the maturity of a particular technology and to allow consistent comparison of maturity between different types of technologies. TRL values range from 1 to 9. The TRL was initially pioneered by J.C. Mankins [2] at the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center in the 1980s as a method to assess the readiness and risk of space technology. Over time, NASA continued to commonly use readiness levels as part of an overall risk assessment process and as a means for comparison of maturity between various technologies. NASA incorporated the TRL methodology into the NASA Management Instruction 7100 as a systematic approach to the technology planning process. The DoD, along with several other organizations, later adopted this metric and tailored its definitions to meet their needs.

2.2. Integration Readiness Level (IRL)

The IRL is a metric to measure the integration maturity between two or more components. Integration Readiness

Levels, in conjunction with TRLs, form the basis for the development of the System Readiness Level (SRL). The IRL values range from 0 to 9. The original IRL scale definitions, as proposed by Sauser [3], have been modified to be consistent with the foundation of the TRL scale and to reflect more closely the indigenous development model. See Table 1for details.

IRLs represent the systematic analysis of the interactions between various components and provide a consistent comparison of the maturity between integration points. Using IRLs assists the systems engineer in identifying development areas that require additional engineering. IRLs also provide a means to reduce the risk involved in maturing and integrating components into a system. Thus, IRLs supply a common measure of comparison for both new system development and technology insertion.

2.3. System Readiness Metrics

There are three system readiness metrics that are computed in the SRA process. These are the Component SRL, Composite SRL, and SRL. System readiness incorporates a TRL and a metric of integration maturity, the IRL. While the TRL provides the metric for describing component knowledge, the IRL is a metric that provides a description of architectural knowledge or how the components are integrated. System readiness provides a snapshot in time of the readiness of the entire system. Sections 2.3.1 – 2.3.3 describe the three system readiness metrics.

2.3.1. Component SRL

A Component SRL is the System Readiness Level of an individual component of the system and its integration links. Component SRLs are used to identify which system components are lagging or may be too far ahead in terms of their readiness and thus require Program Management and/or engineering attention.

2.3.2. Composite SRL

The Composite SRL measures the SRL of the whole system or all of the components of the system integrated together. The SRA approach calculates the Composite SRL by averaging the Component SRLs and rendering the value in a decimal format. As with any calculation involving an average, the user needs to be aware of the potential risk of masking a Component SRL that may be significantly lagging or leading the average.

2.3.3. SRL

The SRL is obtained by converting the Composite SRL to a 1 to 9 integer scale, with 9 being the most ready. The conversion to an integer scale facilitates reporting and interpretation of the results, similar to the conversion of a numerical score to letter grade. This process is described in Section 4.2.

3. The SRA Process

This section describes in detail the System Readiness Assessment process. The approach for conducting an SRA is broken down into three core steps, as illustrated in Figure 1 and discussed in Sections 3.1 through 3.3.

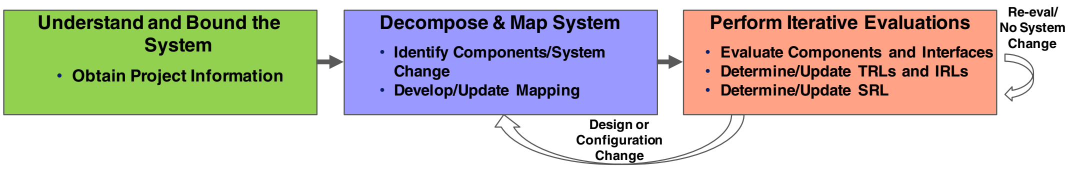


Figure 1 System Readiness Assessment Flow

3.1. Understand and Bound the System

The team performing the SRA gathers program information, which can include capabilities statements, requirements documents, architecture products, context diagrams, test plans, and any other documents that support understanding the system. Product vendor documentation and relevant published reports may also provide additional information to fill in any gaps to develop a complete understanding of the system. For this step, there is close

interaction of the team with the program Lead Systems Engineer (LSE) and Subject Matter Experts.

3.2. Develop System Mapping

Operational Activities	Service Functions (Level 1)	Service Functions (Level 2)	System Components	TRL	System Technologies	TRL
A2.1.1 Activity	1.Service Function	1.1 Service Function	Component 1	4	System Technology	5
A2.1.2 Activity					System Technology	5
A2.1.3 Activity					System Technology	4
A2.1.4 Activity			Component 2	4	System Technology	6
A2.1.6 Activity					System Technology	4
A2.2.1Activity					System Technology	7
A2.2.2 Activity					System Technology	5
A2.2.3 Activity		1.2 Service Function	Component 3	5	System Technology	6
A2.2.4 Activity					System Technology	5
A2.2.5 Activity					System Technology	7
					System Technology	5
			Component 4	7	System Technology	7
					System Technology	7

Figure 2 An Example Mapping of a Subset of a System with TRLs

Create a mapping of the system that provides a relational understanding between the different layers of architecture. At the highest level, this mapping originates with operational requirements and activities. Functions which trace to these operational activities are then generated. System components which perform these functions are identified. The individual components are comprised of technologies. Figure 2 shows an example system mapping diagram for four of the components of a ten component system. This is an example of tracing from the system's operational requirements to its individual components and technologies. A component interface block diagram with ten components is generated (Figure 3). While the efforts to perform data gathering, assessments and calculations increase, the SRA method is scalable to much larger systems. The system mapping and component interface diagrams together serve as the foundation on which SRA analysis is performed. Developing system mappings identifies the linkages and traceability between system components and allows systems to be assessed consistently. All hardware and software components that represent the system are identified. Technologies are mapped to specific components when evaluating TRLs. Mappings are based on what is known at the time and evolve and are updated as the design, architecture or other information changes. The same mapping process can be implemented when doing design or system trade-offs, providing significant benefits and insight into analysis of alternatives.

3.3. Perform Iterative Evaluations

The third step in the process evaluates the system to determine its readiness. The evaluation is conducted iteratively through the development cycle and can be continued throughout the system life cycle. All component and integration links must be evaluated for technology and integration readiness. Figure 3 illustrates an example of component and integration links. TRLs and IRLs are determined using detailed decision criteria and assigned accordingly. As shown in Figure 2, components may be comprised of more than one technology each with its own TRL. The TRL of a component is determined by assigning to it the minimum TRL of the component's system technologies. Hence, the TRL is assessed at the technology level and the SRL is calculated at the component level. This approach for determining a component's TRL is a recommended approach, not a required one. Assessment may be performed at a different level as long as consistency is maintained. The mapping shown in Figure 2 is an illustrative example of a mapping and breakdown approach which carries through the sections for illustrative purposes. The SRL is then computed by a mathematical algorithm that combines TRLs and IRLs (see Section 4.1).

3.4. Criteria Used in Performing Assessment

The SRA process incorporates readiness at three readiness levels: Technology, Integration and System. The scales,

definitions, and decision criteria of each TRL are those developed by NASA and recommended by the Defense Acquisition Guidebook. The IRL concept was originally developed by the Stevens Institute of Technology. An enhanced set of IRL decision criteria shown in Table 1 was developed which includes the evidence description used to assess interface readiness during the SRA.

Table 1. Decision Criteria for Assessing Integration Readiness Level (IRL)*

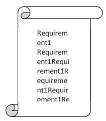
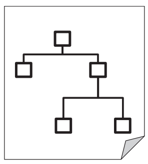
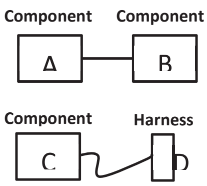
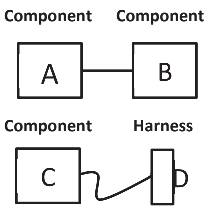
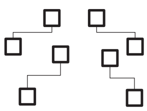
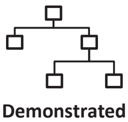
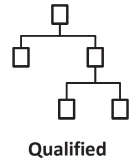
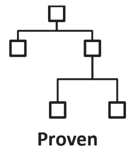
IRL	Definition	Depiction	Evidence Description
0	No Integration		**No integration between specified components has been planned or intended**
1	A high-level concept for integration has been identified.	 Concept	**Principal integration technologies have been identified** Top-level functional architecture and interface points have been defined High-level concept of operations and principal use cased has been started
2	There is some level of specificity of requirements to characterize the interaction between components	 Requiremen	**Inputs/outputs for principal integration technologies/mediums are known, characterized and documented** Principal interface requirements and/or specifications for integration technologies have been defined/drafted
3	The detailed integration design has been defined to include all interface details	 Design	**Detailed interface design has been documented** System interface diagrams have been completed Inventory of external interfaces is completed and data engineering units are identified and documented
4	Validation of interrelated functions between integrating components in a laboratory environment	 Lab	**Functionality of integrating technologies (modules/functions/assemblies) has been successfully demonstrated in a laboratory/synthetic environment** Data transport method(s) and specifications have been defined
5	Validation of interrelated functions between integrating components in a relevant environment	 Relevant	**Individual modules tested to verify that the module components (functions) work together** External interfaces are well defined (e.g., source, data formats, structure, content, method of support, etc.)
6	Validation of interrelated functions between integrating components in a relevant end-to-end environment	 End-to-end	**End-to-end Functionality of Systems Integration has been validated** Data transmission tests completed successfully

Table 1. Decision Criteria for Assessing Integration Readiness Level (IRL)*

IRL	Definition	Depiction	Evidence Description
7	System prototype integration demonstration in an operational high-fidelity environment		**Fully integrated prototype has been successfully demonstrated in actual or simulated operational environment** Each system/software interface tested individually under stressed and anomalous conditions Interface, Data, and Functional Verification complete
8	System integration completed and mission qualified through test and demonstration in an operational environment		**Fully integrated system able to meet overall mission requirements in an operational environment** System interfaces qualified and functioning correctly in an operational environment
9	System Integration is proven through successful mission-proven operations capabilities		**Fully integrated system has demonstrated operational effectiveness and suitability in its intended or a representative operational environment** Integration performance has been fully characterized and is consistent with user requirement

***Disclaimer**:* The IRL scale does not attempt to address or account for programmatic lifecycle activities or responsibilities. This scale is intended to be used to assign integration readiness levels based on the applicable definitions and supported by the evidence descriptions.

*Developed by NSA, Version 1.1

4. Sample Calculations, Interpreting the Results and System Readiness Analysis

4.1. Sample Calculations

This section explains in detail and demonstrates by example the calculations and matrix mathematics used in the SRA process to determine the SRL [3]. Calculating the SRL is a function of the TRL and IRL matrices. The TRL matrix provides a snapshot in time of the state of the system with respect to the technology readiness of its components. The TRL is defined as a vector with n components where TRL_i is the TRL of component i. As was discussed in Section 3.2, TRLs are mapped to specific components for evaluation purposes. The IRL matrix represents the integration of different components with each other from a system perspective. The integration between components i and j is represented by IRL_{ij} in the IRL matrix. The theoretical integration of a component i to itself is denoted by IRL_{ii} and is assumed to be a maximum, i.e. 9, in this SRA approach. Zeroes in the matrix indicate no planned integration. The formation of the TRL and IRL matrices is shown in Equations (1) and (2).

$$[\mathrm{TRL}]_{n\times 1} = \begin{pmatrix} TRL_1 \\ TRL_2 \\ \cdots \\ \cdots \\ TRL_n \end{pmatrix} \quad (1) \qquad [\mathrm{IRL}]_{n\times n} = \begin{pmatrix} IRL_{11} & IRL_{12} & \cdots & \cdots & IRL_{1n} \\ IRL_{21} & IRL_{22} & \cdots & \cdots & IRL_{2n} \\ \cdots & \cdots & IRL_{33} & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ IRL_{n1} & IRL_{n2} & IRL_{n3} & \cdots & IRL_{nn} \end{pmatrix} \quad (2)$$

Figure 3 illustrates an example of TRLs and IRLs for a system architecture with 10 components. The components and interfaces shown in Figure 3 have been identified through the completion of the system mapping process described in Section 3.2.

In the matrices represented, the TRL levels correspond to values 1 through 9 while the IRL values range from 0 to 9. Before performing the matrix math, these values are normalized by dividing by 9, the highest value. For example, an IRL of 9 has a normalized value of 1 for element IRL_{ij} and has the characteristics described in Table 1 with respect to the *ith* and *jth* components. Similarly, an IRL of 5 has a normalized value of $\frac{5}{9}$ or 0.556.

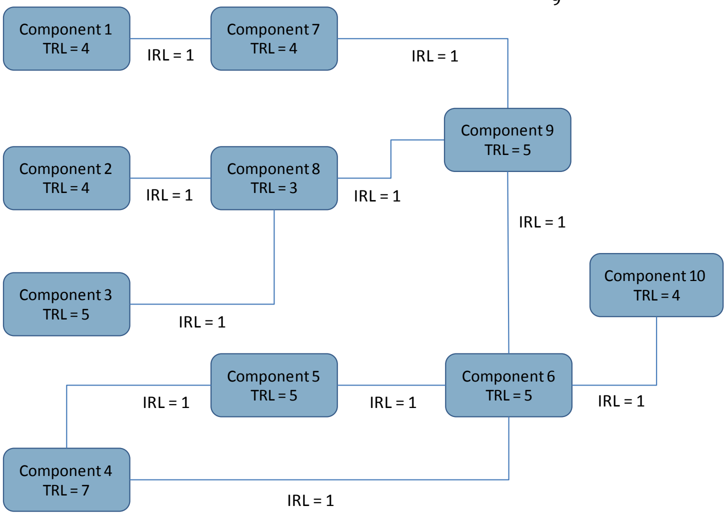


Figure 3 TRLs and IRLs for a 10-Component System

At a minimum, each of the components of a system is connected to one other component. This integration is bi-directional, and it is assumed that the IRL is the same in each direction. Each component is integrated with other components in a specific way and is used to formulate and calculate the SRL.

In order to calculate a value of the SRL from the TRL and IRL values, an SRL matrix is generated by obtaining the product of the IRL and TRL matrices, as shown in Equation (3):

$$[SRL]_{n\times 1} = [IRL]_{n\times n} \times [TRL]_{n\times 1} \qquad (3)$$

The SRL matrix consists of one element for each of the constituent components and, from an integration perspective, quantifies the readiness level of a specific component with respect to every other component in the system while also accounting for the development state of each.

Mathematically, for a system with n=10 components, the SRL is as shown in Equation (4), where TRL_i represent the individual TRLs and the IRL_{ij} are the individual IRLs between the components. SRL_i represents the readiness level of Component *i*, reflecting the readiness of *all* of its connections/interfaces. (Recall that IRL_{ij} represents the IRL only between Component i and Component j.) For the general case of a 10-component system:

$$\begin{pmatrix} SRL_1 \\ SRL_2 \\ SRL_3 \\ \cdots \\ SRL_{10} \end{pmatrix} = \begin{pmatrix} IRL_{1,1} & IRL_{1,2} & \cdots & \cdots & IRL_{1,10} \\ IRL_{2,1} & IRL_{2,2} & \cdots & \cdots & IRL_{2,10} \\ \cdots & \cdots & IRL_{3,3} & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ IRL_{10,1} & IRL_{10,2} & IRL_{10,3} & \cdots & IRL_{10,10} \end{pmatrix} X \begin{pmatrix} TRL_1 \\ TRL_2 \\ TRL_3 \\ \cdots \\ TRL_{10} \end{pmatrix} \qquad (4)$$

The corresponding SRL_i for each component *i* is then divided by m_i, as shown in Equation (5), to obtain its normalized value. The m_i term is the number of integrations of component *i* with every other component as defined by the system architecture. This includes integration of the component with itself. Dividing by m_i also allows each component to be neutrally weighted looking at the component in isolation with its nearest neighbors, yielding well-behaved and consistent mathematical and statistical properties.

$$Component\ SRL_i = \frac{SRL_i}{m_i} \tag{5}$$

The Composite SRL for the system is the average of the Component SRL values, as shown in Equation (6), where n is the number of components:

$$Composite\ SRL = \frac{\left(\frac{SRL_1}{m_1}\right) + \left(\frac{SRL_2}{m_2}\right) + \left(\frac{SRL_3}{m_3}\right) + \cdots + \left(\frac{SRL_{10}}{m_{10}}\right)}{n} \tag{6}$$

Continuing with the example of the 10-component system illustrated in Figure 3, where the TRLs and IRLs have the specified values shown, we generate Table 2. As an illustrative example, the highlighted cell in Table 2 indicates an IRL value of 1 for the integration readiness of the interface between Component 5 and Component 6. As indicated previously, a zero (0) is placed in the matrix where no integration is planned.

Table 2. TRLs and IRLs for 10 Component System

Component IDs		1	2	3	4	5	6	7	8	9	10
TRLs		4	4	5	7	5	5	4	3	5	4
IRLs	1	9	0	0	0	0	0	1	0	0	0
	2	0	9	0	0	0	0	0	1	0	0
	3	0	0	9	0	0	0	0	1	0	0
	4	0	0	0	9	1	1	0	0	0	0
	5	0	0	0	1	9	1	0	0	0	0
	6	0	0	0	1	1	9	0	0	1	1
	7	1	0	0	0	0	0	9	0	1	0
	8	0	1	1	0	0	0	0	9	1	0
	9	0	0	0	0	0	1	1	1	9	0
	10	0	0	0	0	0	1	0	0	0	9

Normalizing the matrix entries, the product $[IRL]_{10x10}$ x $[TRL]_{10x1}$ yields a resultant 10 x 1 column matrix as shown in Equation (7). Each Component SRL is calculated by taking the matrix entry and dividing by its total number of integrations including integration with itself. For example, Component 6 has five total integrations – Components 4, 5, 9, 10 and integration with itself. Thus, the Component SRL for Component 6 is 0.815/5 = 0.163. Table 3 shows each of the Component SRLs.

4.2. Interpreting the Results

The Component SRLs are important, as they provide an indicator of the readiness of the individual component and its associated integrations. Examination of the individual Component SRL values relative to each other identifies those components that are lagging or may too far ahead in their "readiness." This is illustrated in the example results shown in Table 3, where it can be seen that Component 8's SRL is lagging the other system components as it has a lower Component SRL value at 0.127. The fact that the readiness of Component 8 is lagging is brought to the attention of the Program Manager and/or other decision makers for a detailed risk assessment and further analysis.

$$\begin{pmatrix} (1)(.444)+(0)(.444)+(0)(.555)+(0)(.777)+(0)(.555)+(0)(.555)+(.111)(.444)+(0)(.333)+(0)(.555)+(0)(.444) \\ (0)(.444)+(1)(.444)+(0)(.555)+(0)(.777)+(0)(.555)+(0)(.555)+(0)(.444)+(.111)(.333)+(0)(.555)+(0)(.444) \\ (0)(.444)+(0)(.444)+(1)(.555)+(0)(.777)+(0)(.555)+(0)(.555)+(0)(.444)+(.111)(.333)+(0)(.555)+(0)(.444) \\ (0)(.444)+(0)(.444)+(0)(.555)+(1)(.777)+(.111)(.555)+(.111)(.555)+(0)(.444)+(0)(.333)+(0)(.555)+(0)(.444) \\ (0)(.444)+(0)(.444)+(0)(.555)+(.111)(.777)+(1)(.555)+(.111)(.555)+(0)(.444)+(0)(.333)+(0)(.555)+(0)(.444) \\ (0)(.444)+(0)(.444)+(0)(.555)+(.111)(.777)+(.111)(.555)+(1)(.555)+(0)(.444)+(0)(.333)+(.111)(.555)+(.111)(.444) \\ (.111)(.444)+(0)(.444)+(0)(.555)+(0)(.777)+(0)(.555)+(0)(.555)+(1)(.444)+(0)(.333)+(.111)(.555)+(0)(.444) \\ (0)(.444)+(.111)(.444)+(.111)(.555)+(0)(.777)+(0)(.555)+(0)(.555)+(0)(.444)+(1)(.333)+(.111)(.555)+(0)(.444) \\ (0)(.444)+(0)(.444)+(0)(.555)+(0)(.777)+(0)(.555)+(.111)(.555)+(.111)(.444)+(.111)(.333)+(1)(.555)+(0)(.444) \\ (0)(.444)+(0)(.444)+(0)(.555)+(0)(.777)+(0)(.555)+(.111)(.555)+(0)(.444)+(0)(.333)+(0)(.555)+(1)(.444) \end{pmatrix} = \begin{pmatrix} 0.494 \\ 0.482 \\ 0.592 \\ 0.900 \\ 0.705 \\ 0.815 \\ 0.555 \\ 0.508 \\ 0.704 \\ 0.506 \end{pmatrix} \quad (7)$$

Table 3. Component SRLs for 10 Component System

Component ID									
1	2	3	4	5	6	7	8	9	10
Component SRL									
0.494/2	0.482/2	0.592/2	0.900/3	0.705/3	0.815/5	0.555/3	0.508/4	0.704/4	0.506/2
0.247	**0.241**	**0.296**	**0.300**	**0.235**	**0.163**	**0.185**	**0.127**	**0.176**	**0.253**

The Composite SRL is the average of the Component SRLs [Equation (8)]. As with any calculation involving an average, the user needs to be aware of the potential risk of masking a Component SRL that is significantly lagging or leading the average, reiterating the importance of assessing and monitoring the individual Component SRLs.

$$\text{Composite SRL} = [0.247 + 0.241 + 0.296 + 0.300 + 0.235 + 0.163 + 0.185 + 0.127 + 0.176 + 0.253]/10 = 0.222 \quad (8)$$

Composite SRLs are defined on a scale from 0 to 1 with a value carried out to three decimal places. For the calculations in the example above, the Composite SRL is reported as 0.222 with 10 Component SRLs of 0.247, 0.241, 0.296, 0.300, 0.235, 0.163, 0.185, 0.127, 0.176 and 0.253. It could potentially be difficult to understand the difference between system readiness values that are very similar (e.g. 0.247 vs. 0.241 vs. 0.296). Composite SRL values are translated to whole numbers consistent with TRL and IRL scaling for ease of interpretation. To translate the 0 to 1 scale to a 1 to 9 scale, the SRL Translation Model shown in Table 4 is used to map the decimal values to whole number values. Because the System Readiness Assessment is dependent on the system architecture configuration, a SRL Translation Model is generated for each architecture configuration when performing the SRA as shown in Table 4.

Table 4 SRL Translation Model

TRL	IRL	Composite SRL_i	Midpoint Between Levels	Composite SRL_i Range	SRL
9	9	1.000	0.914	.914 - 1.000	9
8	8	0.828	0.750	.750 - .913	8
7	7	0.672	0.601	.601 - .749	7
6	6	0.530	0.467	.467 - .600	6
5	5	0.404	0.349	.349 - .466	5
4	4	0.293	0.245	.245 - .348	4
3	3	0.197	0.157	.157 - .244	3
2	2	0.116	0.084	.084 - .156	2
1	1	0.051		.000 - .083	1

To generate the SRL Translation Model for this example architecture, a Composite SRL_i is calculated for nine system architecture configurations (each with 10 components and 10 integration links) where the TRLs for all of the

components and the IRLs for all of the integration links are set equal to the same value, an integer from 1 to 9. For example, the Composite SRL of 0.051 is calculated by setting the TRL of each of the 10 components equal to 1 and the IRL of each of the 10 integration links equal to 1. The midpoints between each pair of adjacent Composite SRL_i are used as the boundaries for the corresponding Composite SRL_i Range values, as shown in Table 4.

The complete SRL scale and descriptions are given in Table 5. The SRA shown in the example at the beginning of this section resulted in a Composite SRL of 0.222. Using the SRL Translation Model, this translates to a System Readiness Level of 3. This indicates that the immature and high-risk technologies have been identified and prototyped. Through the SRA process, areas of potential concern are identified, documented, and reported.

The SRL calculated in this example is a snapshot in time. It is critical to measure the system readiness at multiple points along the life cycle to avoid pitfalls that can occur when readiness is only assessed once or twice. The SRA for this example was conducted early in the life cycle when all component Integration Readiness Levels (IRLs) had a value of "1." As the system development progresses, the TRLs and IRLs of the components will mature and the SRA is calculated for a second snapshot in time, providing the decision maker with risk assessment information.

SRAs can be performed on any size program and at any time during the system development. The potential technology and integration risks will determine the frequency at which SRAs are performed. Typically, for larger programs, a quarterly SRA is recommended while for small programs SRAs may be performed every month. Once the system has been defined, the system mapping completed, and the initial SRA done, subsequent or follow-on SRAs can be performed in a reasonably short time.

Table 5. SRL Descriptions

Level	SRL* Definition
9	System has achieved initial operational capability and can satisfy mission objectives
8	System interoperability should have been demonstrated in an operational environment
7	System threshold capability should have been demonstrated at operational performance level using operational
6	System component integrability should have been validated
5	System high-risk component technology development should have been complete; low-risk system components
4	System performance specifications and constraints should have been defined and the baseline has been allocated
3	System high-risk immature technologies should have been identified and prototyped
2	System materiel solution should have been identified
1	System alternative materiel solutions should have been considered

* Developed by NSA; derived from the DoD Integrated Defense Acquisition, Technology and Logistics Life Cycle

5. Guidelines for Successful Implementation of the SRA Process

In order to properly and effectively use the SRA Process, a set of guidelines is provided. Adherence to the guidelines is important and provides the basis for successful implementation of the process and the calculation of the SRL. Below is the initial set of guidelines. Over the course of time, as the SRA process is implemented, additional guidelines may be necessary. In addition, the guidelines are accompanied by a brief description of the rationale for the guideline.

GUIDELINE 1

Use the SRL as an indicator of current system readiness rather than for predictive analysis.

Rationale for Guideline 1: NASA initiated TRLs. Integration Readiness Levels (IRLs) followed. To be a System Readiness Level (SRL) indicator, the metric needs to include both TRLs and IRLs (Integration). Do not use the SRL for predictive analysis. The SRL should be combined with another established approach for predictive analysis. The intent of the SRL approach is not to estimate "how long" nor does it measure the level of effort it takes to increase system readiness.

GUIDELINE 2

Only compare SRLs of the same system throughout its life cycle. Compare “your system” as it matures, not two different arbitrary systems.

Rationale for Guideline 2: The SRL is a comprehensive snapshot in time of the readiness of the current architecture (i.e., system) and can be used as a valid indicator of readiness for the system at that time. The calculation of the SRL is dependent on the structure of the system. Adding components and/or interfaces changes the structure of the system. If the structure of the system changes a careful examination should be performed to ensure that inconsistencies are not introduced.

GUIDELINE 3

Systems Engineering guidelines for architectural decomposition of systems recommend decomposing a system into a subset of components or entities for analysis. For SRA analysis, it is recommended to decompose the system into 9 ± 2 components.

Rationale for Guideline 3: The SRA approach is independent of the number of components and the number of integrations in the decomposition. However, because of the averaging of the Component SRLs to obtain the Composite SRL, exceeding the recommended 9 + 2 decomposition may produce the effect where the “weakest link” or SRL of the least mature component begins to be masked. This effect will be amplified as the number of components increases.

GUIDELINE 4

Let the SRL approach “work for itself.” Avoid interim or nodal comparison of TRLs and/or IRLs that result in setting an expectation for what the aggregate or composite readiness/maturity should be.

Rationale for Guideline 4: Do not solely use the SRL, a single number, as the basis for decision making but rather take into consideration all the lower level metrics, i.e. Component SRLs, when making design and acquisition decisions. Specifically, use these Component SRLs to identify components or areas of systems development that are lagging or too far ahead in their readiness progression.

GUIDELINE 5

When no integration is planned between two components, set the IRL value equal to 0. If integration between components is planned but not yet established, set the IRL value equal to 1.

Rationale for Guideline 5: Setting the IRL values in this way completes the matrix, alerting the user to the fact that there is no interface between two components (IRL = 0) or that the interface is planned but not yet established (IRL = 1).

6. Summary

System Readiness Assessment (SRA) is an innovative methodology that provides a system level metric to help reduce integration issues, one of the leading causes of system development failures. The SRA methodology provides decision-makers a snapshot of a system’s holistic state of maturity and quantifies the level of component-to-component integration during system development, helping to improve system performance management. Implementation of the SRA methodology aids decision makers in identifying both programmatic and technical risk areas. The SRA methodology is currently being validated through a number of program pilots. Further validation of the method will be achieved through broader application across multiple enterprises. Future research areas include mathematically sound weighting techniques and leveraging the principles of the SRA framework to model system availability and for other Risk Management techniques.

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